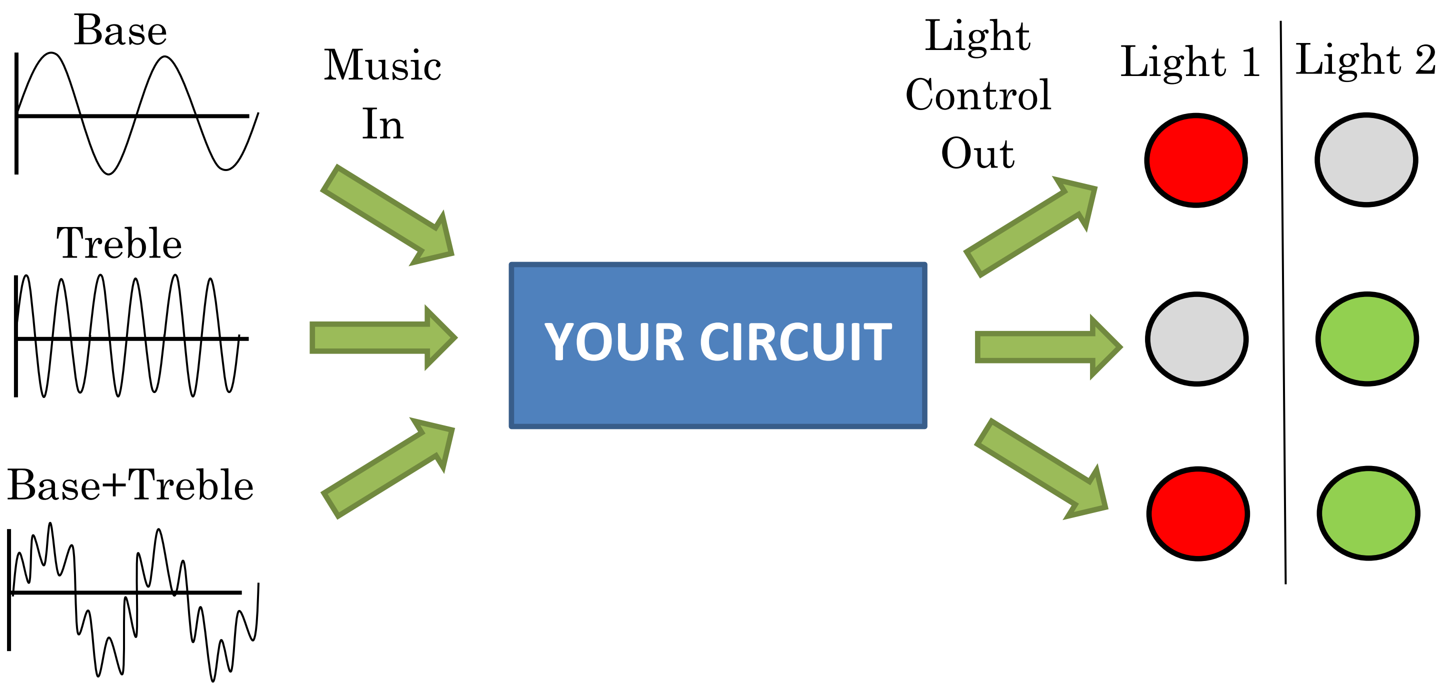
MIE346 – Design Assignment 1 (4% of total grade)

Due Date: Feb. 17th, midnight (online submission)

Your goal is to design a **color organ**, a device often used at concerts and similar venues to light up different colors of lights depending on the frequency content of the incoming music signal. For instance, one light may turn on for bass (low frequencies), and one for treble (high frequencies). Commercial versions often have multiple lights corresponding to different bands of frequencies. If you have questions about the interpretation of the problem, please ask the instructor. A sample video of a color organ in use is included in the link below. A graphical representation of your task also follows:

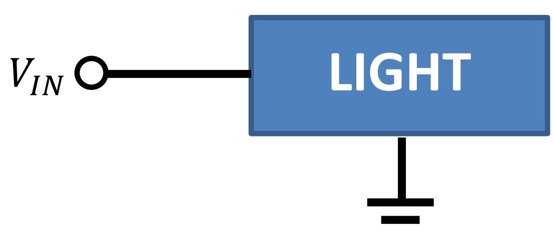
Sample Implementation: https://www.youtube.com/watch?v=cgk3o8s_N1E



To make this a more specific problem, here are a few details:

- Your solution should detect **two** bands only; bass and treble. You define the exact frequencies on your own, keeping in mind that the incoming signal is **music** (think about human hearing).
- Assume that the lights are given to you; they can be treated as a 'black box' component with two states:

$V_{IN} < 3\,V$ = LIGHT OFF $\qquad\qquad$ $V_{IN} > 3\,V$ = LIGHT ON



- It is safe to assume that the lights are self-powered and draw no input current.

- The incoming music signal ranges from ~50-100 mV peak-to-peak at low volumes to ~500mV-1000mV peak-to-peak at high volume. You can assume an ideal music signal source (zero output resistance).
- You can assume power supplies of any desired (finite) voltage and ideal op-amps are available.

Questions – 5 points each, 40 points total

1. Write an **Engineering Specification** for your problem. This specification should list all of the numerical and functional requirements of the finished product. It should also include any assumptions you make about the problem, and any added insight or added requirements that come from your interpretation of the problem at hand.
2. Draw a block diagram of a **Conceptual Design Solution** to the above problem; blocks can be filters, amplifiers, etc. Describe the theoretical operation of your solution.
3. For each **filtering element** in your circuit, draw a **desired** Bode plot – in other words, specify the function of the block by drawing the frequency response you want at each step.
4. Select a circuit to implement each block in your diagram from Question (2). Explain the reasoning behind each choice of circuit. Note that you may choose a circuit which produces a different Bode plot than the one you selected in Question (2), if you think it will be better in some way. Similarly, feel free to return to earlier parts and modify your circuit as needed to make it function correctly. If you want circuit blocks that go beyond simple single-pole/single-zero transfer functions (such as band-pass filters, or circuits with under-damped poles), see the tutorial problems and the lecture problems, especially those labelled 'TOOLKIT EXAMPLE,' for circuit ideas. The function of most circuits is clearly labelled, and can also be seen from the transfer functions.
5. Design the filter circuits you have selected to implement the Bode plots you selected in Question (2). In other words, select component values (resistance, capacitance, etc.) for all passive components.
6. Now, round the values to **standardized, real-world** decade values for all resistors, capacitors, and inductors. Given these values, derive the transfer function and sketch the Bode Plot for each block.
7. Draw the schematic diagram for your complete system. Derive or select component values for any parts not selected in Question (6). You may earn bonus marks in this part by making a more 'real-world' design – for example, by selecting specific op-amps, power supply voltages, specifying connectors for input and output, etc.
8. Given a high-volume input of two pure sine waves, $v_{in}(t) = Asin(\omega_1 t) + Bsin(\omega_2 t)$, where $A = B = 750\, mV$ and ω_1 is $100\, Hz$ and ω_2 is $5\, KHz$, roughly sketch the output at each block/stage of your solution.